ROLES OF NATURAL HISTORY COLLECTIONS[1]

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ABSTRACT

Natural history collections have always contained a wealth of data: genetic and phylogenetic information stored as an inherent part of the samples of organisms themselves, and biogeographic, ecological, and biographical information stored in the labels that are affixed to them. Together, a preserved organism and its label are a scientific specimen that has great intrinsic value. Separately, the label is a piece of paper with meaningless inscriptions upon it, and the plant, spider, microbe, mushroom, or bird, though carefully preserved, is just so much dead organic matter. Natural history collections are the repository of the vouchers for the documentation of what we know about the diversity of living things—what species exist and where, what their habitat requirements are, what ecological associations they have with other species, what useful biochemical products they might generate, and who collected them and has studied them. Before the advent of computers, natural history collections were physical databases from which geographic or ecological analyses and reports could be extracted by human visitation and transcription, usually a laborious and time-consuming task. However, such analyses are invaluable for land-use planning, pharmacognosy, conservation biology, range management, forestry, agriculture, and a host of other applications, including scientific studies of the ecology and systematics of the species being examined. Computerization of label data makes such reports on distribution and ecology of species more readily available to potential users; they add value to the data. Interconnecting the databases brings robustness to the information that natural history collections can provide to policy-making bodies; appreciation of robust data will lead in turn to appreciation of the collections from which those data were taken. Interconnectivity requires that collections personnel abandon competition in favor of achieving a common goal: the discovery and description of the world's biota.

When I was first asked to write this paper, I was told that the topic I would cover should be "the role of natural history collections in relationship to the National Biological Service." I have taken the liberty, while keeping biological surveys in mind, of expanding my topic to include the roles (plural) of natural history collections, not only in relation to the NBS but also in relation to society at large, and to each other.

I begin with a broad-brush statement about the activities of biological surveys in general, and their relationship to collections. Next, I touch on the history of natural history collections—what their roles have been in the past, and how those roles have changed (or not) over the years. Then, I present the perceived roles of natural history collections as they stand and as I think they need to become. Finally, I come full circle to the relationship between natural history collections and biological surveys, and the National Biological Service in particular.

Throughout, when I use the term "natural history collections" I mean collections both of animals and of plants. It is true that botanists have been slow to give up the name "herbarium," a word that de Tournefort and Linnaeus used to mean a collection of preserved specimens of plants. I suspect that we botanists might much more readily have become natural historians of plants had our collections continued to be called, as they were before de Tournefort and Linnaeus (Radford et al., 1974), *hortus siccus* or *hortus mortus*! However, I for one consider herbaria to be natural history collections, and refer to them as such except in the discussion of the history of the two sorts of collections.

MISSIONS OF BIOLOGICAL SURVEYS

IDENTIFY NATURAL (LIVING) RESOURCES

Most biological surveys around this country have as their charge the documentation of the biota of the state or other geographical entity to which they belong. The political entities that established the surveys expect them to provide information to policy-making bodies that will allow for "better decision-making" with regard to those living resources

[1] Craig Freeman assisted with many aspects of this paper, John Simmons pointed me to literature about the history of collections, and Vivian Nolan retrieved it from various libraries, including those of the National Science Foundation and the Smithsonian Institution. I thank both the people and the libraries.

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ANN. MISSOURI BOT. GARD. 83: 536–545. 1996.

(as defined in human economic terms). To be able to provide the information requested, biological surveys personnel must extract it from the literature, or perform original research (C. C. Freeman, pers. comm.; Cameron, 1929; Kim & Knutson, 1986; Rautenbach & Herholdt, 1990).

PERFORM TAXONOMIC/ECOLOGICAL STUDIES

It would be desirable, from the political standpoint, for the literature to contain reports of studies that have already been done that would answer the questions of the legislatures. Very frequently, this is not the case, and biological surveys personnel undertake original investigations.

Often, the requests for information involve questions about the ecology of certain organisms. The ecological research, in turn, often involves questions about the taxonomy and phylogeny of those organisms. The answers to these questions rest squarely in natural history collections that the biological surveys personnel may maintain themselves or have access to in natural history museums (Chernoff, 1986; Pettitt, 1994).

If there is no collection, the first step in the research is to make one. Even if the consulted literature does contain a taxonomic, phylogenetic, and ecological analysis of the organisms of interest (so that the biological survey person does not have to do original research), that study would have been based on natural history collections that voucher and document the work of the author(s) of the paper (e.g., Yochelson, 1969; Conference of Directors of Systematics Collections, 1971; Pettitt, 1994).

EXAMINE ENVIRONMENTAL IMPACTS

Biological surveys often examine the environmental impacts of human actions (Kim & Knutson, 1986; Pettitt, 1994) within their own purview or those of neighboring states. Again, it is natural history collections that document the spread of introduced taxa and decline of native species, the current distribution of taxa, and the relationships among organisms, which live, not in clades but rather in interconnected, interoperable habitats. The phylogenetic studies that are done by systematists using the same collections provide the historical context for the evolutionary emergence of the organisms within those habitats.

DEVELOP MONITORING, MANAGEMENT, AND CONSERVATION PROTOCOLS

Within museums lie solutions to problems in conserving natural resources (Shropshire & Shropshire, 1991). The biological surveys are often expected to develop plans to evaluate, monitor, and mitigate all manner of ecological phenomena. Their reports are vouchered and documented by specimens placed in natural history collections; without those vouchers, the facts that their studies have uncovered are in question. These protocols must be developed in light of collections; otherwise there is no basis for the pursuit of one management method over another (Conference of Directors of Systematics Collections, 1971; Rautenbach & Herholdt, 1990; Pettitt, 1994).

Relationship of Biological Surveys to Natural History Collections

From these examples, it is clear that natural history collections are fundamental to all that biological surveys do. Where there is no collection, the first job of a survey is to form one. Such was the situation in 1804–1806, when President Thomas Jefferson, having just acquired the huge Louisiana Territory for the fledgling United States, sent Meriwether Lewis and William Clark and their companions to make a survey of the headwaters of the Missouri River and territories thereabout, to include observations of the minerals, soils, climate, peoples, and animals in their diverse kinds, as well as "... the dates at which particular plants put forth or lose their flowers or leaf, times of appearance of particular birds, reptiles or insects" (Cutright, 1969). Jefferson was himself a naturalist of note, who kept detailed records of the requirements of many sorts of plants that he attempted to grow in his experimental garden, and of observations of the behavior of animals on his plantation (Martin, 1952). Lewis and Clark took their charge from the President seriously, as it was meant, and brought back bales of specimens of various sorts of organisms, sometimes at the risk of life and limb (Cutright, 1969). This leads us to the discussion of the history of natural history collections. I shall in a moment return to Lewis and Clark.

History of Natural History Collections

The geneses of natural history collections are, I have found, in general understood differently by botanists and zoologists. The instigation for collecting plants, and the simple method of their preservation, led to a different beginning for herbaria than for collections of animals, for which specimen-conservation techniques development is still in full swing (Ouellet, 1985; Hawks, 1990).

The origins of natural history collections extend back through Western history to Ptolemy's academy

in third-century B.C.E. Alexandria, which was a palace that contained botanical and zoological gardens for teaching purposes, and cloisters and lecture rooms for students and teachers (Bateman, 1975). Pliny's first-century C.E. *Historia Naturalis* not only describes this academy, but gives our science its name (Porter, 1991). The development of collecting between that time and the Renaissance, unfortunately, is one of war, looting, and plunder, but, by the fifteenth century, palaces in Europe contained collections of books, art (much of which had natural subjects), and the odd natural oddity (narwhal tusks interpreted as unicorn horns, for example) (Ritterbush, 1969; Bateman, 1975).

ZOOLOGICAL COLLECTIONS

Through the sixteenth century and well into the seventeenth, "cabinets of the curious," that contained shells, fossils, minerals, casts from nature, and botanical and zoological art, became a common possession among European nobility (Alexander, 1979; Impey & MacGregor, 1985; Hooper-Greenhill, 1992). Some of these cabinets were actually whole rooms, others were truly pieces of furniture designed to contain objects that represented the entire world in miniature. These objects, however neatly stored, were not scientifically arranged, nor were they available to the public for study—they were private collections amassed for private, primarily aesthetic, purposes (Ritterbush, 1969). Although I do not know this, I would wager that the owners entered into collection-building competitions: "mine is bigger than yours"—the same syndrome that is perpetuated among some museums and collectors today.

The first of the public museums of natural history (which included, from its inception, two herbaria) was that in Paris, founded in 1635; the first university museum was established at Basel in 1671 (Bateman, 1975). The Ashmolean Museum at Oxford University, established in 1683 (Alexander, 1979; Lintz, 1991), seems to be the first to have official curators, a catalog, and a set of regulations for visitors. These early museums, however, were more of art than of actual natural objects, because of the difficulty of preservation of animals. When Charles Wilson Peale, an American, worked out the use of arsenic in taxidermy in the late 1700s, that obstacle was overcome, and natural history collections began to acquire, for the first time, long-lasting collections of birds and mammals (Porter, 1991).

Peale's Philadelphia Museum, started in 1786, does not by many years postdate the establishment of the British Museum of Natural History in 1753 (Lintz, 1991) or the first formal natural history collection in North America, the Charleston Library Society, started in 1773 (Alexander, 1979). Even the venerable Paris Museum only began to acquire birds at the very end of the eighteenth century; by 1793, that collection included 493 skins.

HERBARIA

Modern herbaria, in the post-Renaissance scientific sense, have a history that is at least a century longer than zoological collections. If we accept herbaria as natural history collections (which in this day and age they certainly are), then the oldest formal natural history collection for scientific purposes of any sort (and this, most zoologists do not know) is the oldest herbarium in existence, which dates from 1523 (Ogilvie, 1985). The herbarium of Gherhards Cibo dates from 1532 (Radford et al., 1974), and the herbarium of the University of Padua, begun in 1545, was the first institutional herbarium (Shetler, 1969), and therefore the first university natural history collection. In the New World, the establishment of the first herbarium (at Winston-Salem, North Carolina, in 1772) predates by a year the oldest zoological collection on this continent (Shetler, 1969; Porter, 1991).

The original use of the word "herbarium" is much older even than the sixteenth century. Herbaria once were rooms in medieval monasteries, in which were kept, usually hanging from the rafters, bundles of dried herbs that were to be used for flavoring food, for counteracting mildew and body odors in linens and clothing, and, of course, for medicinal purposes. For an image of such a room, think of the garden and monastery in Franco Zefferelli's lush cinematic production of Shakespeare's *Romeo and Juliet*—in the herbarium, Juliet is presented with the sleeping draft that had been compounded from the herbs hanging overhead. In addition, these examples of dried herbs would have been used in teaching younger monks about the plants and their uses. Thus, the monastery herbarium was both the forerunner of the modern teaching collection of plants, and continuation of the "herbalist" period of botanical history (Radford et al., 1974).

My purpose in painting this sketchy history of natural history collections is three-fold: First, that the term "natural history collections" as a designation of scientific resources should be understood to include herbaria; we should not use the phrase "natural history collections and herbaria" to refer to the collections enterprise, because that distinc-

tion sets us apart rather than bringing us together. Second, that biological surveys have always made and relied upon natural history collections. Third, I stress the connections between herbaria and collections of other sorts of organisms because it is the history of herbaria that is rooted most firmly in the service to society ethic (i.e., the medicinal and agricultural uses of plants). It is this linkage of herbaria, and thereby collections of other sorts of organisms, to societal service that will serve systematics well as it grows into the roles outlined for it in *Systematics Agenda 2000.*

Roles of Natural History Collections in the Past

Originally, natural history collections made it possible for their viewers to have some notion of the biota and artifacts of distant places that they themselves could not visit (Lintz, 1991; Hooper-Greenhill, 1992). Collections were made for entertainment value as "curiosities" (Impey & MacGregor, 1985), and hidden from competitors until their value could be estimated. Plants and shells were collected for their aesthetic value; the early collections of objects were valued originally as the subjects of paintings and drawings, rather than for themselves (Ritterbush, 1969). Collections were made because interest in the natural world was a major preoccupation of Renaissance learning (Impey & MacGregor, 1985), and, according to Albert Bickmore (first director of the American Museum of Natural History), for "teaching our youth to appreciate the wonderful works of the Creator" (Alexander, 1979). The education function evolved later into a view of nature as an open book, from which "the Birds and Beasts will teach thee!" as stated the tickets to Peale's Philadelphia Museum (Lintz, 1991).

Only gradually were repositories for the natural history collections made by survey expeditions such as that of Lewis and Clark identified and established. Despite his intense interest in natural history (Martin, 1952), and his charge to Lewis and Clark to make collections of the organisms they encountered, Jefferson (with, for him, unusual lack of foresight) did not make provision for the storage and curation of the specimens thus acquired. Many of the specimens that Lewis and Clark collected were dispersed (Porter, 1991); only a few were returned to an appropriate U.S. repository. Though the Congress continued to send out many more expeditions that collected specimens during the next several decades, it was not until 1879 that the official U.S. repository for such collections was established: the United States National Natural History Museum (Cowan, 1969; Porter, 1991). Meanwhile, some of the states had initiated natural history collections. Here, New York is a telling example: The New York State Natural History Survey was started in 1836, and that Survey generated a Cabinet of Natural History (that is, collections) as its first task. The cabinet was physically located in Albany in 1843, seven years after the institution of the Survey itself (Porter, 1991). Only after the collections were made were ecological studies instituted. In the nineteenth century it was recognized that collections must be made because they were critical to the progress of science, but provision for the conservation and preservation of the specimens was a harder sell. Today, it is not only the latter but also the former that must be promoted, although natural history collections today occupy prime real estate: for examples, the California Academy of Sciences in Golden Gate Park (San Francisco), the Smithsonian Institution on the National Mall (Washington, D.C.), the Field Museum of Natural History on Lakeshore Drive (Chicago), and the Missouri Botanical Garden on Shaw and Tower Grove Avenues (St. Louis). The taxpayers and contributors that provided this real estate, and the curators who through the decades have built the collections, deserve an appropriate return on their investments (Cowan, 1969; Allmon, 1994; Shetler, 1995).

Present Roles of Natural History Collections

Today, the roles of natural history collections, as is often stated in the literature, are two-fold: research (Lemieux, 1981; Edwards, 1985; Lintz, 1991; Stansfield, 1994), sometimes called the "inner museum function," and education, the "outer museum function" (Humphrey, 1991; Allmon, 1994). Some authors add service to this list as a third role (Laerm & Edwards, 1991; Pettitt, 1994). The things that natural history collections *do*, however, may be summarized in a few statements. Of course, it is possible and reasonable to expand this list into its myriad component parts (as, for example, in *Systematics Agenda 2000*), and there are contexts in which I do, too. However, for the purposes of this paper I will use the "executive summary" form.

Natural history collections record the world's biota in space and time, and document what we do and do not know about that biota (Michener et al., 1970; Conference of Directors of Systematics Collections, 1971; Lamanna, 1976; Dessauer & Hafner, 1984; Duckworth et al., 1993; Anonymous,

1994; Federal Biosystematics Group, 1995). Further, natural history collections are the fundamental and indispensable resource for biological surveys, which study living organisms to understand ecosystem dynamics and conservation of living diversity (Irwin et al., 1973; Edwards & Grotta, 1976; Kim & Knutson, 1986; Duckworth et al., 1993; Anonymous, 1994; Federal Biosystematics Group, 1995). Natural history collections voucher economically important organisms, research in systematics, population biology, ecology, genetics (and a host of other fields), and provide specimens and knowledge for education and exhibits (Michener et al., 1970; Irwin et al., 1973; Lemieux, 1981; Chernoff, 1986; Duckworth et al., 1993; Allmon, 1994; Anonymous, 1994; Federal Biosystematics Group, 1995). Natural history collections are the basis for public and formal education programs (Lemieux, 1981; Allmon, 1994; Anonymous, 1994; Federal Biosystematics Group, 1995). Natural history collections are irreplaceable assets of the greatest value (Brain, 1990).

It is this repository-of-knowledge function, I suspect, that keeps most systematists constantly defending and promoting natural history collections. We understand, and we must constantly be vigilant that others understand, that human beings learn about new things *only in the context of what they already know.* Natural history collections are *the* context for what we already know about the diversity of living things on this planet. Collections are the vouchers for the knowledge to be passed to succeeding generations (Lamanna, 1976). It is estimated that that knowledge is exceedingly skimpy: Perhaps only 1 to 5, or at most, 15 percent of the species on Earth have been apprehended by science. In our research function as the describers of new species, we despair of our ability to discover and describe the remaining 85 to 99 percent (which means tens of millions to a hundred million or more species) in the 40 or so years we have (if we are lucky) before they are mostly destroyed (Anonymous, 1994). But think! How much more difficult would that task be without the comparative research collections we already have of the things that *are* known to science?

Thus, natural history collections personnel have several goals that must be reached. First, we must preserve against the forces of entropy the heritage that is represented by the some two billion specimens (Duckworth et al., 1993) in natural history collections around the world (approximately 400 to 500 million in the U.S. alone). This goal requires constant improvement of our techniques of specimen conservation (Lemieux, 1981; Hawks, 1990), because many if not most of these specimens could not be collected again—too many habitats have been destroyed, and the cost of collecting expeditions has become too high to replicate something someone else has already done. Second, we must continue to collect, to gather new knowledge, and to process that knowledge for the benefit of society and biodiversity itself. Third, and most importantly, we must constantly educate—not just youth, the public, and politicians—but also ourselves.

As natural history collections curators or collections managers or researchers, we must school our competitive instincts into cooperative ones. No longer should the goal be to demonstrate that Kew has more specimens than Paris, the American Museum more than Berlin, my own herbarium in Kansas more than Oklahoma's or Colorado's; in short, to demonstrate that: "mine is bigger than yours." We must teach ourselves better public relations (Grove, 1970; Irwin et al., 1973), political maneuvers (biologists and particularly systematists are especially lax in this area), and yes, even better business practice (Malaro, 1994). We must develop and follow long-range plans and careful acquisitions policies (Hoagland, 1994; Malaro, 1994) that are coordinated among museums to avoid duplication of effort. We are together in a race against time: "Gentlepersons of Collections, rev your engines!" But first, examine your motives. There is no time for the pettiness of competition in this race. Our common goals must be to partition the work of diversity discovery and collection (Anonymous, 1994), conservation and preservation (Hawks, 1990; Herholdt, 1990), and become much better ambassadors both for the work we do, the collections within which we work, and the uncounted millions of species we serve.

Those are lofty, admirable, and incredibly difficult goals. But how do we attempt them, and from whence will the funding come? I believe that we have a start. It is a beginning that needs improvement and modification, not to mention a "pedal to the metal," but a beginning nonetheless.

Twenty to twenty-five years ago, a number of reports and working papers produced by committees of the fledgling Association of Systematics Collections and similar bodies (Manning, 1969; Conference of Directors of Systematics Collections, 1971; Edwards & Grotta, 1976; Humphrey & Clausen, 1977) suggested that computerization for collections management was a direction that natural history collections ought to take. During the intervening two decades, a number of things have happened in this area: (1) quite a number of natural history collections have digitized at least part of their spec-

imen data, (2) the realization of the need for data standards has occasioned the development of some of these within certain collections communities (Biological Collections Data Standards Workshop, 1992), (3) a number of monographers have realized the value of computerizing the data of the specimens they borrow, (4) there have been workshops about natural history collections computerization and networking, and (5) the Research Collections in Systematics and Ecology program of the National Science Foundation has instituted a special category for collections computerization that supports several database-development projects around the country. Most curators and collections managers now recognize the value of digitized collections information, and are willing to expend effort to computerize (Owen, 1990; Allen 1993; Cohn, 1995).

However, progress in this area has been slowed by two factors: (1) the learning-curve difficulties experienced by collections curators and managers in trying to understand fully relational database management systems and Internet connectivity, and (2) the lack of cooperation and agreement within the larger community on database structure, semantics, and syntax—that is, what are collectively called standards, which are important especially as we interconnect our databases. We *must* get past these barriers. As Shetler (1995) has so aptly said, "If our generation doesn't figure out how to provide better access to the information stored in our existing collections, then the next generation may not be able to defend keeping these collections."

Information Management

NOT ONLY FOR COLLECTION MANAGEMENT

Many collections have begun the databasing process with excellent intentions: information provision on a case by case basis to other systematists and natural historians who work within a collections environment. Such databases allow the home collection to develop loan-management software that accommodates the idiosyncratic needs of that particular museum. While such database capabilities are useful within a small sphere, they do little for outreach beyond the systematics collections community.

NOT ONLY FOR THE PURPOSES OF SINGLE STUDIES

Many monographers have databased many specimen records for use in print publications. But once the publication is produced, the data lie dormant in files accessible only by outmoded and outdated programs. There also have been databases produced specifically to answer certain ecological questions. But these databases alone do little to contribute to the store of human knowledge if they are left in storage on a floppy disk in a desk drawer. They contain data plus keystrokes plus analysis—the value-added components—that turn raw data into information. Why should this be withheld from others? Why not share it? In so doing, investigators fulfill both a scientific and a societal obligation.

NATURAL HISTORY COLLECTIONS DATA INFORM AND ILLUMINATE POLICY DECISIONS

Natural history collections have for decades claimed that the data contained in the specimen labels, vouched for by the specimens themselves, are an inestimable information resource for land and resource management, range science, agriculture, pharmaceutical chemistry, DNA sequencing for phylogenetic studies, and myriad other fields. This claim is, in fact, true. However, to put those data to use has for the same duration of years been a time-consuming and tedious task of transcription and collation of the data, requiring that a thorough investigator visit one to several collections or obtain the specimens on loan. Those persons who need these data, but who are not inclined to sit for many hours in quiet among the cases, tend to disbelieve the claim of value of specimens because of the tedium involved in extracting the information. Bad decisions have sometimes been made about the use of biological resources because individuals found it easier to guess or to follow preconceived notions than to obtain real information, even though the needed data were right at hand in the closest natural history collection.

Computerized collections catalogs. In the 1970s, when farsighted curators began to apply computer tools to collections management tasks, the argument for doing so was that natural history collections could more easily track loans, care for specimens, and keep catalogs (e.g., Humphrey & Clausen, 1977). The computerization effort was seen as a boon internal to the systematics community. The accessibility of the data for ecologists and others was regarded as a useful byproduct. Collections were to support systematic research first; managing collections more efficiently by computerizing was to be for the benefit of collections personnel.

Value-added data. Formal curatorial catalogs of natural history collections date at least from the establishment of the Ashmolean Museum; most probably they are older than that, stemming from the jumbled days of the "curiosity cabinets." Originally, catalogs were listings of the kinds of objects

in a collection. With the advent of computerized "catalogs," the meaning has mutated, become much more expansive, and the catalogs, which we now call databases, infinitely more valuable. There are those who fear that the rapid accessibility of information in computerized catalogs will render, in the minds of policymakers and funding bodies, the specimens themselves obsolete. In fact, exactly the opposite is true. The "evolved catalog," because it provides readily accessible information, renders the specimens that voucher it even more valuable. Remember? In the days before computerization, the specimens and their data were often being ignored altogether. Now, the data cannot be ignored, but likewise they are worthless unless vouchered by well-cared for specimens. People who use data want to know that they are real data; those people are therefore more likely, rather than less, to appreciate natural history collections for the inestimably valuable resource that they are.

COLLECTIONS AS CONSERVATION TOOLS

In fact, to humans, *knowing* something almost always makes that something more valuable. Make it possible to *use* the knowledge and the valuation skyrockets. Think, for instance, of oil. Petroleum. Nasty black stuff that bubbled out of the earth; once, it was to be avoided! And now look—humans value "black gold" as much as precious metals, are ready to mortgage entire economies, and even go to war for it, because we can use it because we know its properties. I submit that the same could be true of "biodiversity"—humans must come to know and use biodiversity (and it is to be hoped that that use will be sustainable, unlike the use of petroleum). Then, and only then, it will be *valued* and therefore *saved.* Natural history collections have an important role to play in this scenario. As the caretakers of the human record of biodiversity and what we know about it in the formal sense, presumably we care about the biota of Earth and want to see biodiversity saved.

The task of finding ways to get humans to know, and therefore value, and therefore save biodiversity is one of the great challenges to human ingenuity in our time. Natural history collections contain a vital portion of the information on ways of knowing and utilizing biodiversity. We must have the strength of our convictions that our kind of science has a necessary place among those ways of knowing and utilizing, but we must get beyond our hubristic notion that our science, as we have practiced it in the past, is sufficient to supply all of the needed "ways of knowing and utilizing." We must become entrepreneurial thinkers; we must find ways to add value to our data, and we must make it available and rapidly accessible. By providing high-quality information (value-added data), we will increase the value of our collections, and of biodiversity, in the estimation of our publics.

And so, the question becomes: How do we increase the value of our data and thereby our collections and thereby biodiversity? I believe that finding answers to this question is a role that natural history collections must play now and in the foreseeable future. The data from a single collection, even a large one, cannot by itself answer the big questions. However, those data, interconnected with the data from other collections can together provide a robust answer. We must be continuously conscious of the need to provide outputs of our science that are useful to society. That, recursively, will make our collections and biodiversity more valuable. This means turning our thinking outward.

We must get out from behind our specimen cases—either that, or invite society in, or both. One way or another, we must engage our publics by making it easy for them to know, understand, use, value, and save. I think that this will be easier together than it is for any one institution, or even a group of nine or ten institutions, alone. Natural history collections have in the past five years taken the first, hesitant steps on the road to interconnectivity. It is my purpose here to encourage us all to get in shape and begin the marathon.

INTERCONNECTIVITY

I am borrowing "interconnectivity" from cyberspace and bringing it into the very human level of relationships among natural history collections personnel because the word "community" has been overworked and used to mean something far less grand than I propose. Natural history collections must together become a nationwide museum: a group of interconnected, interrelated, interactive, interdependent nodes on the Internet. As Benjamin Franklin said, "We must all hang together, or we shall surely all hang separately." We must make ourselves indispensable—together we are, individually we are not. We must view ourselves as working not at Missouri Botanical Garden or the University of Kansas or the Smithsonian or Montana State University or the Paleontological Research Institute or the Field Museum or the University of Wyoming or the New York Botanical Garden or Louisiana State University, but rather in the greatest collection of all: the collection of all natural history collections. The good part is that to build

this grand museum we do not need to change physical location, we merely need to get better at cooperating and appreciating each other's strengths. We do not have to become homogenized; in our diversity is our strength. We can easily grow beyond the "mine is bigger than yours" syndrome, because *ours* will be, virtually, enormous.

BENEFITS FOR NATURAL HISTORY COLLECTIONS

In the 1970s, the thought was that computerization would be a good collections management tool (e.g., Conference of Directors of Systematics Collections, 1971; Humphrey & Clausen, 1977), and that analysis of the data by other scientists would be a useful byproduct of the effort. I hope that I have made clear that this notion is actually a better concept if it is turned inside out. We should be computerizing and interconnecting our data for use by other scientists and society. Collections management is a minor, though useful, byproduct of that effort. The benefits of outward-looking and interconnected data sets for natural history collections science itself are many:

(1) The generation of more robust answers to systematic, phylogenetic, and biogeographical questions, because we will have access to ecological data sets as well. Shared, combined information is good information. Good information drives good science; the two are reciprocally illuminative.

(2) "Gap analysis" of our knowledge—what do we know about which taxa? Are data hiding in some small but precious collection somewhere, underused and unappreciated and out of context? Together with information from other collections, seamlessly combined via the Internet, small collections become immediately more valuable, and large ones can fill in interstices without needing more cases, more compactors, more supplies for the adoption of orphaned collections. The large collections, by sharing data and software with the smaller ones, can actually preserve those collections (and the education that is based on them) in place. More education means more knowledge, more appropriate use, more tendency to save.

(3) In turn, knowing what we do and do not know will help us make better acquisitions policy decisions, so that systematics professionals can cover new ground rather than unknowingly repeating our steps.

(4) Interconnectivity will allow each natural history collection to achieve greater outreach than any one could alone. Some collections have no exhibit space—their collections could be featured at one that does. Others may have magnificent exhibit space but might be missing a component needed for a really spectacular display—and that small collection across the country might have the needed contribution. These are win-win situations.

(5) Interconnectivity, because it will allow us to make better decisions, will also reduce our tendency to reinvent the wheel, will reduce competition for scarce resources, and will promote the possibility (because we will be providing robust information that is valuable to society) of finding new resources. Together, we can achieve an efficiency of scale that not even the largest institution can do alone.

All of these benefits of interconnectivity together allow us to move forward with the primary task: discovering, classifying, and understanding the world's biota. Again, efficiencies of scale come into play. Dare I dream that we might one day avoid the production of nomenclatural synonyms and homonyms, and the waste of precious time that such represent, because we can quickly and efficiently look beyond the physical collection and library at hand to see if what we are about to do has been done before?

BENEFITS FOR SOCIETY

The benefits to society of interconnected natural history collections lie in the value-added component. Good information, that is, a more robust data set with value added, drives good policy decisions, allowing for the greatest value to be "mined" from biodiversity in a sustainable fashion. "Good" here includes the concepts of ready accessibility and availability, quality control and assurance, and completeness. It is the last that is more nearly achieved together. We know we will not be able to provide complete information about biodiversity anytime in the near future, if we have thirty to a hundred million more species to discover. But, we do know that there is more information in *all* natural history collections about any one known species than there is in any *one* natural history collection about that species (Conference of Directors of Systematics Collections, 1971). Certainly, the information about all known species in all natural history collections has synergistic, emergent properties that cannot be imagined based on a single collection.

The educational value to society of having all the information from all the natural history collections at the touch of fingertips on a keyboard cannot be estimated. This education, on the Internet, can take many forms: classroom study, individual exploration, discussions with curators via CU-See Me or

even more cutting-edge technologies, or informal education opportunities set up and designed to be Web-accessible, to name but a few. Together, we have the wherewithal to put in motion the excellent ideas of individuals who alone may be unable to realize them.

I would like to make one final point here that brings our future role full circle to one of the past roles of collections: entertainment. The "cabinets of curiosities" were for the entertainment and personal satisfaction of their owners. People like to be entertained. They like to feel that they have ownership in something larger than themselves. If they are entertained, they will support and contribute. If there is any doubt of this, just take a look at professional athletic teams. The Internet offers us the opportunity to make natural history collections *entertaining*. Let us not lose the chance to gain new contributors because we are too focused on formal educational tools, formal scientific endeavor, and the esoterica of which only systematists are capable. An easy leap, once we grow past our tendency to compete among ourselves, is to let our enormous "curiosity cabinet" be their enormous "curiosity cabinet"—and I believe that people will feel that they have ownership in something larger than themselves, and will contribute to it. Certainly a nationwide virtual museum will be an entity larger than any of us, but we will all have ownership in it. Go collections! Go connections!

Natural Partners

Biological surveys in general are, of course, the most natural of partners of natural history collections in this enterprise. There are many users of collections data, and these also will be served by natural history collections interconnectivity. But, it is the work of biological surveys, with their connections to natural resource users, that are most understandable to our common general public and the decision-making bodies that rely on them. In turn, biological surveys cannot provide good information to drive good decisions without natural history collections (LaRoe, 1995). Biological surveys and natural history collections are already inextricably interconnected. Both sides of the partnership benefit from ready accessibility of information and appreciation, one by the other, of the role that each plays in the societal arena.

The National Biological Service of the United States has a slightly different character than the state-level biological surveys about which I have been speaking, in that it sees itself as an organizer of existing information, and a catalyst for needed work throughout the nation. It plans to be a clearinghouse, a networking node that will put potential collaborators in touch with each other and with needed information. Again, interconnectivity. Natural history collections have everything to lose if we do not engage in the several partnerships that will be thus formed, and everything to gain if we do become a strong, interconnected web that studies and conserves an increasingly fragile web of life.

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